RETROFIT PATH TO NET-ZERO ENERGY BUILDINGS

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Stabilizing climate change will require an 85% reduction in current greenhouse gas (GHG) emissions. Buildings consume directly nearly 40% of the energy supply. Newer technologies such as geothermal, wind and photovoltaic systems have more recently been applied to housing. The challenge is to achieve cost-effective, simple net zero-energy housing with no GHG emissions in cold northern climates where solar insolation is available only 12-16% of the time. This paper focuses on a retrofit approach to an existing low energy building using only solar energy to achieve net-zero energy.

The current building (built 1998) integrates 5 approaches to achieving low energy use: site, spatial design and orientation; efficient house envelope; efficient appliances and lighting; renewable energy systems; and occupant conservation behavior. The house is a 2400 ft2 two-story cantilevered ranch oriented south, with a length/width ratio of 2. The house is partly bermed, with R values of 40, 27, 3.3, 6 and 16 for the roof, walls, windows, doors and slab, respectively. Tight house construction provides 0.05 air changes per hour (ach). An 80% efficient heat recovery ventilator provides fresh air at 0.3 ach. The calculated heat loss value for the house is 3 Btu/ft2/DD, with an envelope heat loss of 45 million Btu's in a 6500 DD climate All appliances are Energy Star rated. Most lighting in the house is highly efficient T8 fluorescent bulb valence lighting or CF bulb fixture lighting. Overall electrical consumption averages 280 kWh per month. The current backup system is a 90% efficient sealed-combustion oil-fired boiler with a 40-gallon indirect fired hot water tank. Heat distribution has 5 heating zones and includes basement radiant heating and baseboard heating upstairs. Solar heat is collected from 200 ft2 of south facing windows, and an 8 ft. by 12 ft. south facing greenhouse (installed 2002), totaling about 27.5 million Btu's. 75% of the hot water load is provided by 64 ft2 of solar collectors (installed 1999) with an 80-gallon storage tank that feeds into an indirect-fired 40-gallon hot water heater. A 2.5 kW grid-connected photovoltaic solar electric system (installed 2003) provides about 4000 kWh per year, including 600 kWh of excess electricity. Occupant behavior includes reducing thermostat settings to 60 degrees F at night, minimal use of the electric clothes dryer, and occasional cold water clothes washes. Backup oil use has decreased from an initial value of over 250 gallons per year in 1998 to an (estimated) under 120 gallons for the 2006-2007 season.

A detailed analysis of the energy budget and cost effectiveness of each component of the overall design will be presented, with modifications that will achieve net-zero energy use. These include: use of movable insulation, added insulation, 1 kW of additional photovoltaic panels, electric heat for the solar backup tank, and replacing the oil-fired boiler with an electrically heated source of hot water.